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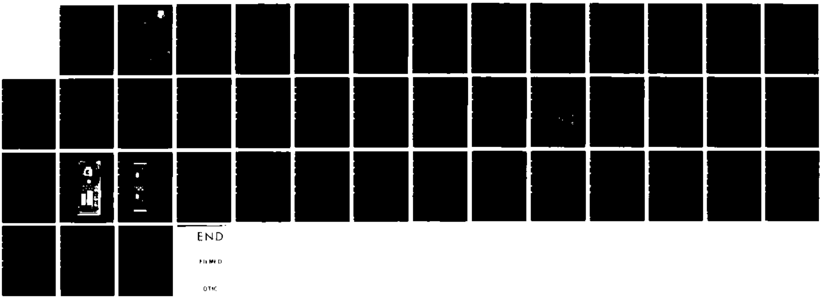

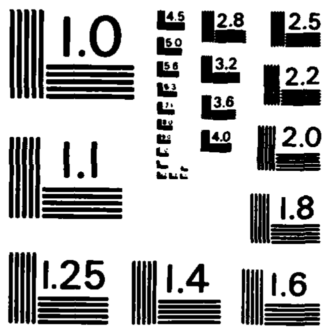

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RADC-TR-84-102
Final Technical Report
May 1984

PORTABLE REAL-TIME CLOCK

Frequency Electronics, Inc.

Marvin Meirs

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Report defines program objectives and technical problems. Report describes technical approach and specifies the final results and conclusions.

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Item # 17 Continued

Field	Group
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Item # 18 Continued

(XCOCXO)
Time-Delay Signal Output, Synthesizer

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

ILLUSTRATIONS

SECTION I

PROGRAM DESCRIPTION

1.1 Background

In June of 1978, Frequency Electronics was awarded a contract to perform the necessary research and development to advance the state of the art in Cesium beam tube technology and applications to a point that would make it feasible to design and fabricate a portable Cesium Beam Frequency Standard having performance characteristics equivalent to that of the existing non-portable units.

The current production model of the Cesium Beam Standard is Model FE-5440A which is presently used in the 616A program and other airborne, shipboard, and ground support systems. The frequency and time signals produced by the Cesium Standard are extremely accurate with tolerances for accuracy and stability being on the order of several parts per 10^{-11}.

1.2 Program Objectives

A summary of the objectives set forth for the design of the Portable Real Time Clock is given below. These objectives cover only broad functional areas of the design and development program.

1) Develop a light weight Cesium Beam Tube that would make it feasible to design a Portable Real Time Clock having the specified capabilities and accuracies.

2) Investigate and complete the redesign of the electronic control loops associated with the Cesium Beam Tube. This was a necessary goal if the required weight reduction of the unit were to be realized and the final unit be a truly portable unit.

3) Design, fabricate and evaluate the various electronic assemblies and the Cesium Beam Tube and Resonator.

4) Design, develop, fabricate and test two (2) Portable Real-Time Clock (PRTC) feasibility models based on Cesium Beam Tube technology which will provide clock-drive and time-of-day signal outputs.

5) The Time Scale of the feasibility models shall be on Universal Coordinated Time. They shall be capable of accepting information from external sources, and will be capable of synchronization upon operator command. The PRTC shall be capable of being powered by ac, dc, external or internal power source.

1.3 Summary

Frequency Electronics has successfully completed the program with the design, fabrication, and testing of two portable units. The new portable unit is known as the Portable Real Time Clock (PRTC) and its electrical characteristics have been proven to be equal to or better than those of the existing non-portable standards.

The PRTC measures 5-7/32 inches high by 13-1/4 inches wide by 19-1/4 inches deep and weighs 39 pounds. The total weight of the PRTC including the internal battery exceed the design goal of 30 pounds by 9 pounds. The unit occupies approximately 1330 cubic inches of space which is a 40 percent reduction in space requirements when compared to a typical non-portable cesium standard.

SECTION II

TECHNICAL DESCRIPTION

2.1 PRTC Functional Description

A functional block diagram of the Portable Real Time Clock is shown in Figure 1. The block illustrates the new single loop system concept implemented ir the PRTC. A functional description of the PRTC us | the block diagram shown in Figure 3 is given in ' paragraphs that follow.

The Cesium Beam Resonator, A1, provides the primary frequency reference. The Cesium Beam Resonator is an atom-microwave device that as a resonant frequency of the (4,0) --> (3,0) hyperfine energy-level transition of Cesium 133 in a weak magnetic field (C-field).

The resonant frequency of the resonator is 9,192,631,771.59 Hz (9.192^{+} GHz) and with the single exception of magnetic fields, the transition frequency is completely independent of all environmental conditions. The resonator receives excitation energy of 9.192^{+} GHz from modulator and multiplier assembly A5. The resonator assembly acts as a detector to

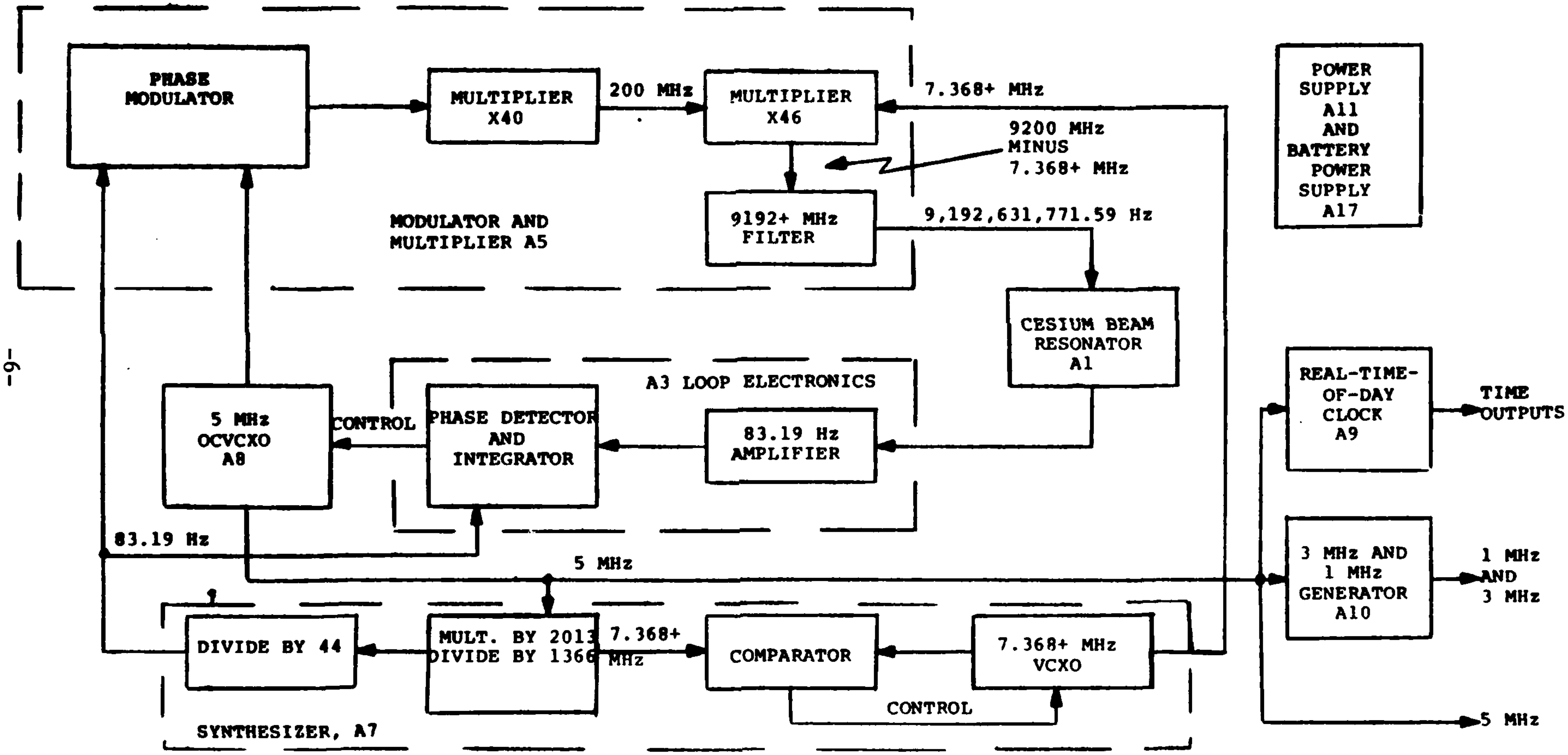


FIGURE 1. PRTC BLOCK DIAGRAM

detect the 83 Hz that is used by the A3 electronics to synchronize the 5 MHz oven controlled, voltage controlled, crystal oscillator (OCVCXO), assembly A8. Four assemblies, A1, A3, A8 and A5, form a phase locked loop that maintains the accuracy of the output of the 5 MHz oscillator.

2.1.1 A1 Cesium Beam Resonator

Significant parameters of the new light weight resonator that was developed for the PRTC program are:

A. Line width < 800 Hz

B. Signal to noise > 58 dB/Hz

C. Signal to background > 6

D. Short-Term stability < 3×10^{-11}

2.1.1.1 Improved Cesium Beam Tube Technology

The largest single item contributing the most size and weight to Cesium Beam standard is the Cesium Beam Resonator. This item weighs 20 pounds in non-portable standard models. It was decided at the outset of the PRTC program that a major redesign of this item could yield a weight saving of almost 50 percent. Also, a careful redesign of the resonator housing could result in a 50% reduction in the volume of the unit.

The Cesium Beam resonator "A" and "B" magnets were redesigned to reduce their weight from 3.5 pounds to 1.0 pound. This weight reduction was accomplished without any degradation in the magnetic field supplied by these magnets. A magnetic field in excess of 9,000 gauss was obtained.

The Cesium Beam Resonator A1 assembly was redesigned to reduce its size by 40 percent. This was done without sacrificing performance or changing the basic design. To attain this reduction, the height and width were shortenend while the 16.5-inch length was maintained. In addition, the VAC-ION pump was placed on the outside of the Cesium Beam Tube.

The new Cesium Beam Resonator, developed for the PRTC, weighs 11 pounds and occupies a space of 129 cubic inches. Thus, the redesign effort resulted in a new smaller Cesium Beam Resonator for the portable unit that has all the performance characteristics of its larger non-portable unit counterpart but is 40 percent smaller in volume and 45 percent lighter.

2.1.2 A3 Loop Electronics

The A3 loop electronics provide the phase detection and integration that is required in the phase lock loop to process the detected 83 Hz error signal and develop the d-c control signal that is used to correct the 5 MHz oscillator. The A3 loop electronics provide a 83 Hz gain of 2000 and a 3 dB bandwidth of 10 Hz.

2.1.3 A5 Modulator and Multiplier

The A5 assembly receives the 5 MHz output of the 5 MHz OCVCXO and the 83 Hz output of the A7 Synthesizer. The input 5 MHz signal is phase modulated at an 83 Hz rate. This signal is then multiplied by 40 to 200 MHz in a transistor multiplier. The 200 MHz signal drives a step recovery diode which multiplies it by a factor of 46 to 9.2 GHz. This signal is then mixed with the 7.368^{+} MHz signal from the A7 synthesizer to obtain the 9.192^{+} GHz signal for the Cesium Beam Tube.

2.1.4 A7 Synthesizer

The synthesizer receives the 5 MHz signal from the 5 MHz oscillator, A8, and uses it to synthesize the 7.368^{+} MHz reference signal that is supplied to the A5 module. This is accomplished by using a 7.368^{+} MHz voltage controlled crystal oscillator (VCXO) in a phase locked loop configuration. The 5 MHz crystal oscillator output is multiplied by a factor of 2013/1366 to obtain the 7.368^{+} MHz reference signal required to control the output of the 7.368^{+} MHz VCXO. The output of the VCXO and the synthesized 7.368^{+} reference signal are compared by a phase comparator which, in turn, issues the necessary error-correcting frequency control signal to the VCXO. The range of control of the 7.368^{+} MHz VCXO is 250 Hz and its output is +6 dBm. The synthesizer also divides the 5 MHz signal by a factor 60,104 to develop the 83 Hz signal that is used by the A5 module to phase-modulate the 5 MHz crystal oscillator signal.

2.1.5 A9 Real Time Clock

The real time clock module uses the output of the 5 MHz crystal oscilaltor to develop real time data and associated mark, timing and data transfer signals.

2.1.6 A10 Generator

The A10 generator module uses the output of the 5 MHz crystal oscillator to develop the 1 MHz sinusoidal output and the 3 MHz squarewave output.

2.1.7 A11 Power Supply

The A11 power supply module uses state of the art power supplies equipped with phase modulated switching regulators. The supply has been designed for minimum ripple and switching spikes. The switching frequency is 27 kHz with a ripple amplitude of less than 20 millivolts. The amplitudes of the high frequency spikes are less than 40 millivolts. The efficiency of a switching regulator is 65 percent. The overall efficiency of the A11 power supply, including linear regulators, is 53 percent.

2.2 Technical Specifications

Electrical and Environmental Specifications of the PRTC are presented in Table 1, PRTC Technical Specifications and in Figure 2, Short-Term Stability and Figure 3, Phase Noise Spectrum.

TABLE 1

PORTABLE REAL TIME CLOCK

TECHNICAL SPECIFICATIONS

ELECTRICAL

ACCURACY:	$\pm 1 \times 10^{-11}$ @ room temperature $\pm 3 \times 10^{-11}$, maintained over a temperature range of −40°C to +65° C and magnetic fields up to 0.2 millitesla (2 gauss) peak.
REPRODUCIBILITY:	$\pm 1 \times 10^{-11}$
SETTABILITY (Frequency:)	$\pm 3 \times 10^{-13}$ Potentiometer adjustable "C" Field.
LONG-TERM STABILITY:	$\pm 1 \times 10^{-11}$
SHORT-TERM STABILITY (5 MHz):	See Figure 1
AVERAGING TIME (SEC.):	$\Delta f/f$
.0001	8×10^{-9}
.001	1×10^{-9}
.01	2×10^{-10}
.1	3×10^{-11}
1	5×10^{-12}
10	1×10^{-11}
100	3×10^{-12}
1,000	1×10^{-12}
10,000	3×10^{-13}
SSB PHASE NOISE (5 MHz):	See Figure 2
OFFSET FROM SIGNAL:	Phase Noise (1 Hz BW)
Hz	dB
10^1	120
10^2	130
10^3	150
10^4	155
10^5	155
WARM-UP TIME:	20 minutes from −28° C
SINUSOIDAL OUTPUTS:	5 MHz, 1 MHz, via front panel outputs.
OUTPUT VOLTAGE:	0.9 to 1.5 Vrms into 50 ohms.
HARMONIC DISTORTION:	Down more than 40 dB from rated output.
NON-HARMONICALLY RELATED OUTPUT:	Down more than 80 dB from rated output.
LOOP TIME CONSTANT:	1 second and 20 seconds.
SQUARE WAVE OUTPUT 3 MHz:	2.5 VP-P minimum into 75 ohms, rear panel only.

TABLE 1

PORTABLE REAL TIME CLOCK

TECHNICAL SPECIFICATIONS (CONT'D)

ENVIRONMENTAL

TEMPERATURE,	
Operating:	$-40°C$ to $+65°C$. Frequency change $< 2 \times 10^{-11}$ with respect to frequency at 25° C.
Non-Operating:	$-62°$ C to $+75°$ C. The ion pump must be operated continuously for extended storage above 35° C, or periodically at lower storage temperatures.
HUMIDITY:	Operating range: 95% humidity, from $-28°$ C to $+65°$ C. Frequency change $< 1 \times 10^{-11}$ from $-28°$ C to $+50°$ C with respect to frequency at 25° C, 50% humidity.
ALTITUDE:	Frequency change 0 to 15.2 km (50,000 ft.), $< 2 \times 10^{-12}$.
MAGNETIC FIELD:	0 to 0.2 millitesla (0 to 2 gauss) dc or peak ac at 50, 60 and 400 Hz; frequency change less than $\pm 2 \times 10^{-12}$. No permanent damage while operating in magnetizing field of 2000 ampere-turns/meter (25 oersteds) dc to 1 Hz.
VIBRATION:	MIL-E-16400 MIL-E-5400 frequency shift $< 2 \times 10^{-11}$.
SHOCK:	MIL-E-5400
CRASH SAFETY:	MIL-E-5400
EMC:	MIL-STD-461 and MIL-STD-462
VOLTAGE REQUIRED:	22 to 30 Vdc.
POWER CONSUMPTION:	
During Warm-up:	75 watts max.
After Warm-up:	48 watts max.
STANDBY BATTERY:	
Battery Capacity:	1 hour @ 25° C ½ hour @ $-28°$ C and $+65°$ C
Charging Rate:	16 hours
Battery Switch-over:	Automatic

TABLE 1

PORTABLE REAL TIME CLOCK

TECHNICAL SPECIFICATIONS (CONT'D)

TIME-OF-DAY CLOCK

Manual Clock Controls:	Set and Add/Subtract
TIME-OF-DAY OUTPUTS:	
Second Mark:	± 6V, 10 microseconds wide. Rear panel (2 each) individually buffered.
Real-Time Data:	± 6V, 20-bit serial output (hours, minutes, seconds BCD). Rear panel (2 each) individually buffered.
REAL-TIME DATA TRANSFER CLOCK:	± 6V, 100kHz, synchronized square wave. Rear panel (2 each) individually buffered.
REAL-TIME TRANSFER GATE:	± 6V, 200 microseconds wide. Rear panel (2 each) individually buffered.
TIME SCALE ADJUSTMENT:	UT + Time Adjust.
1 PPS:	+ 10V ± 1V into 50 ohms (20 microseconds wide; rise time 50 nanoseconds) front panel only.
1 PPM:	+ 4V ± 1Vdc into 50 ohms (10 microseconds wide). 2 rear panel outputs, individually buffered.
1 PPS/1 PPM Isolation:	40 dB (10 kHz to 10 MHz).
1 PPS/1 PPM Jitter (Leading Edge):	5 nanoseconds rms referenced to 5 MHz output.
TIME SCALE:	1 PPS and 1 PPM adjustable with thumbwheel switches over a range of 1 second in discrete steps of 100, 10, and 1 millisecond; and 100, 10, 1 and 0.1 microsecond.
COINCIDENCE (1 PPS/1 PPM):	1 PPS leadedge, 1 PPM trailedge; and second mark trailedge coincident within 100 nanoseconds.
SYNCHRONIZATION (1 PPM/1 PPS):	Automatic with Preset Advance to the leading edge of an external sync pulse.
SYNC ERROR:	± 1.0 microseconds.
TIMING FAULT OUTPUT:	Normal: 3 to 5.5V. Fault: 0 to 0.5V.

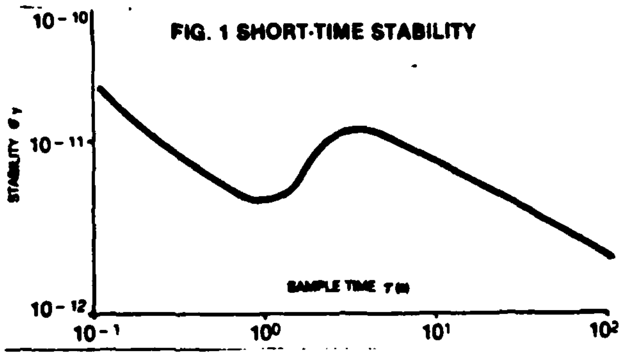


FIGURE 2. SHORT-TERM STABILITY

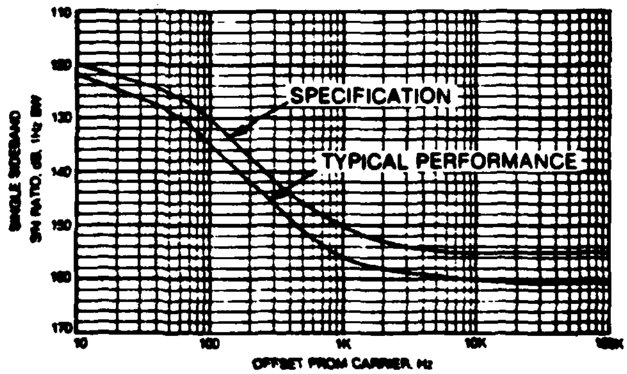


FIGURE 3. PHASE NOISE SPECTRUM

2.3 Mechanical Design

The mechanical specifications for the Portable Real Time Clock are as follows:

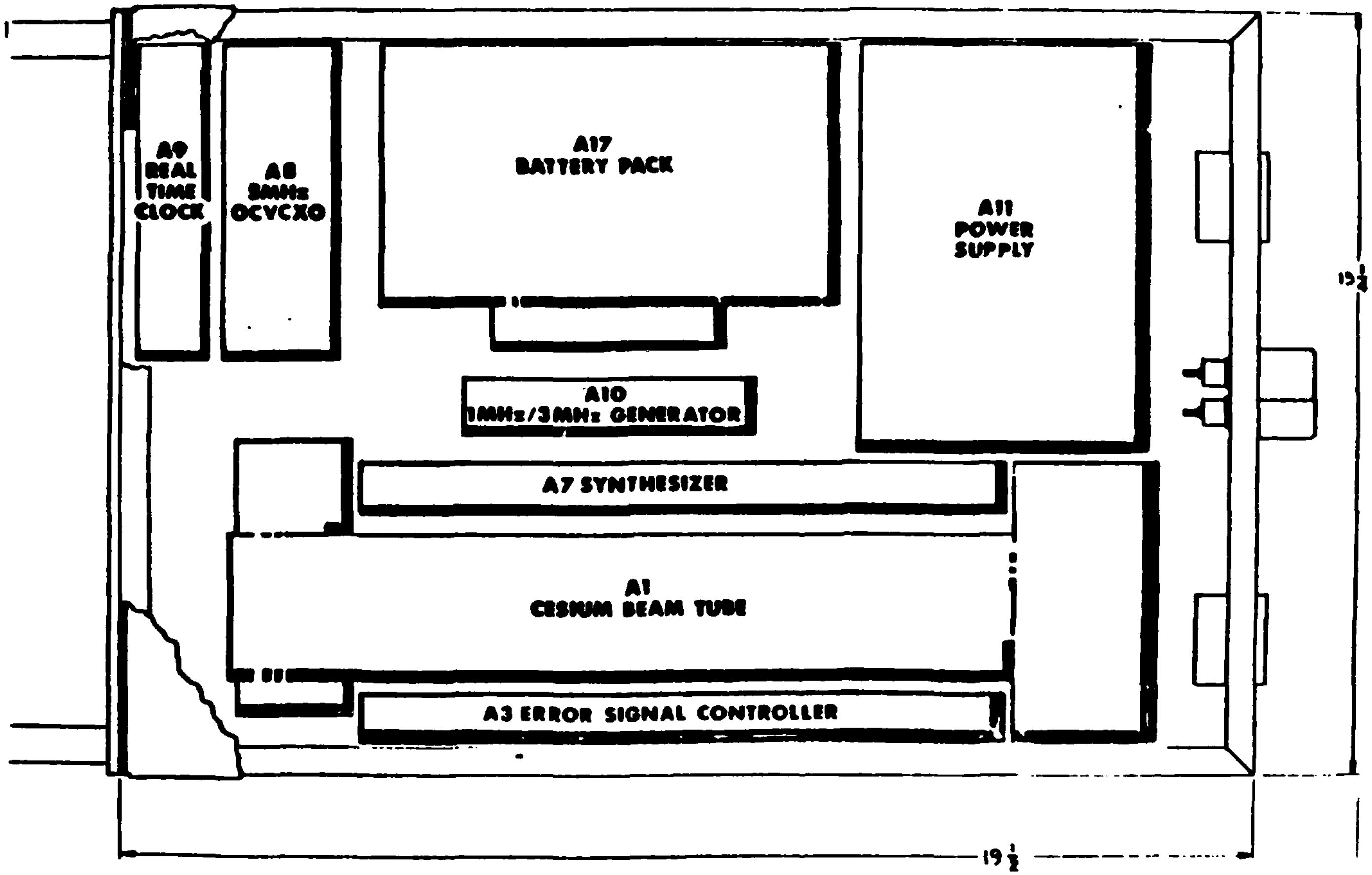
A. Size - 5-7/32" high, 13-1/4" wide, 19-1/4" deep.

B. Weight - 39 pounds, including 1-hour battery pack.

C. Tube Life - Cesium Beam Tube life is 3 years minimum.

Figure 4 shows the mechanical layout of the major assemblies in the PRTC. The following lists the major assemblies of the PRTC:

	MODULE
A1	CESIUM BEAM TUBE
A3	ERROR SIGNAL CONTROLLER
A5	MULTIPLIER
A7	SYNTHESIZER
A8	5 MHZ OCVCXO
A9	CLOCK
A10	1 MHZ/3 MHZ DIVIDER
A11	POWER SUPPLY
A17	BATTERY PACK



PORTABLE REAL TIME CLOCK
(PRTC)
MODEL FE-5450A

Figure 4

2.4 Environmental Characteristics

The Portable Real Time Clock has been designed to meet the environmental requirements set forth in Table 1. The PRTC was subjected to environmental testing including electromagnetic interference and radiation testing, as a part of the research, design and development program. The PRTC has passed all of the environmental tests.

The environmental tests were conducted by independent environmental testing laboratories. Their test reports along with the associated test data are available for inspection at FEI's facility in Mitchel Field, N.Y. Table 2 lists all of the first article tests performed and data submitted.

2.5 Operator Controls, Indicators and Input/Output Receptacles

The operator controls, indicators and input and output electrical receptacles on the Portable Real Time Clock are shown and identified in Figure 5.

TABLE 2 LIST OF FIRST ARTICLE TESTS AND TEST DATA

- Pre-Environmental-Production Inspection Test Data
- Environmental Test Report (East/West Technology Laboratory)
- Environmental Test Data:
  - Pre-Altitude Test Data
  - Altitude Test Data
  - Humidity Test Data
  - Humidity (2nd Cycle) Test Data
  - Humidity (5th Cycle) Test Data
  - Post Humidity Test Data
  - Post Vibration Test Data
  - Post Shock and Crash Safety Test Data
  - Post Explosion Test Data
  - Post Inclination Test Data
  - Post Magnetic Environment Test Data
  - Temperature Test Data (-40°C)
  - Temperature Test Data (+65°C)

TABLE 2 LIST OF FIRST ARTICLE TESTS AND TEST DATA (CONT'D)

- Pre-Environmental Production Inspection Data
- Pre EMI, Radiation, and Temperature-
  Production Inspection Test Data
- EMI Test Report (All-Tronics Laboratory)
- Radiation Test Report (Jaycor Laboratory)
- EMI, Radiation, and Temperature Test Data:
  - Pre-Radiation Test Data
  - Post Radiation Test Data
  - Post EMI Test Data
  - Temperature (-40°C) Test Data
  - Temperature (+65°C) Test Data
- Post EMI, Radiation, and Temperature-
  Production Inspection Test Data

FIGURE 5 PORTABLE REAL TIME CLOCK CONTROLS, INDICATORS AND CONNECTORS, SHEET 1 OF 2

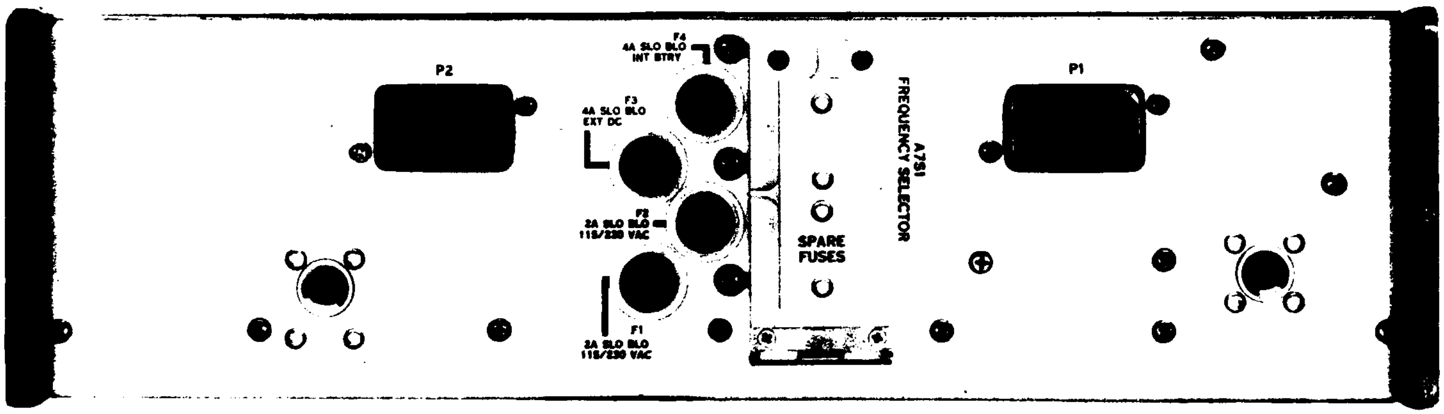


FIGURE 5 PORTABLE REAL TIME CLOCK CONTROLS,INDICATORS AND CONNECTORS,
SHEET 2 OF 2

APPENDIX A

SET-UP AND OPERATING INSTRUCTIONS

A 1.0 PREPARATION FOR USE:

A 1.1 Remove top cover, set internal battery switch S1 to "ON" position.

A 1.2 Apply DC power.

NOTE:
ALLOW 20 MINUTES WARM-UP TIME FOR CESIUM BEAM RESONATOR SIGNAL LEVEL AND CRYSTAL OSCILLATOR FREQUENCY TO STABILIZE. CHECK ALL METER POSITIONS BEFORE STARTING ALIGNMENT PROCEDURE.

A 2.0 ALIGNMENT PROCEDURE:

A 2.1

A) Set the LOOP switch to "OPEN" position.

B) Set the MODULATION switch to "OFF" position.

C) Set the TIME CONSTANT switch to "FAST" position.

D) Set the METER function to Position "8".

E) Adjust DC offset for minimum meter reading.

F) Adjust "Oscillator Adjust" control to obtain maximum indication on meter and lock control.

G) Set MODULATION switch to "OPER" position.

H) Set LOOP switch to "OPER" position. After approximately 15 seconds, the operate light (green) should come on, then press reset button. The system is now operating in normal condition.

A 3.0 PHASE LOCKING AND FREQUENCY OFFSET

A 3.1 A front panel ZEEMAN INPUT connector is provided to enable the Cesium Beam Tube to be calibrated against a known ZEEMAN INPUT.

A 4.0 TIME-OF-DAY CLOCK OPERATING PROCEDURE

A 4.1 The Real Time-Of-Day Clock provides the user with a digital readout display of real-time in hours, minutes, and seconds. It provides outputs of 1 PPS at the front panel; and real- time data, and a 3 MHz squarewave at output connector P2 on the rear panel.

A 5.0 TO OPERATE CLOCK

A 5.1 To operate the Real Time-Of-Day Clock, set the CLOCK OPER/TIME-HOLD switch to CLOCK OPER. The Real Time-Of-Day display will run and show the time in hours, minutes, and seconds on the front panel numeric LED display and readout.

NOTE

UNDER INTERNAL BATTERY OPERATION, ACTIVATE PUSH TIME DISPLAY SWITCH TO ILLUMINATE LED NUMERICAL CLOCK DISPLAY.

A 6.0 SETTING TIME-OF-DAY CLOCK

A 6.1 Set CLOCK OPER/TIME HOLD switch to TIME HOLD. Check reference time and push ADD/SUB switch to add or subtract, while simultaneously depressing the HOURS, MINUTES, and/or SECONDS button, to reference time setting seconds to two (2) seconds later than true reference time. When true reference time reaches Portable Real-Time Clock time, set the CLOCK OPER/TIME HOLD switch to CLOCK OPER.

A 7.0 1 PPM RESET

A 7.1 To reset the 1 PPM pulse to within $\leq$ 100 nanoseconds delay from time coincidence with any selected 1 PPS output over a one (1) minute period, activate the 1 PPM RESET button and note that:

(a) The SECONDS count goes to 00, and

(b) The MINUTES count advances to the next minute.

A 8.0 UNIVERSAL TIME (UT) SET

A 8.1 The Universal Time (UT) SET control allows for correction of the SECONDS TIMING to National Bureau of Standards corrections issued periodically for variances in standard time. Each actuation of the UT SET button will subtract one (1) second from the real-time. (Delay the seconds count by one (1) second).

A 9.0 SYNCHRONIZATION

A 9.1 To synchronize the clock 1 PPS, 1 PPM and second mark to the leading edge of an external sync pulse automatically with a preset advance, proceed as follows:

(a) Apply synchronizing pulse to SYNC IN connector on the front panel.

(b) Depress SYNC ARM pushbutton.

(c) SYNC ARM indicator will light.

(d) Upon occurrence of clock synchronization to the external sync pulse, the SYNC ARM light will be extinguished.

A 10.0 CLOCK DISPLAY ILLUMINATION (BATTERY OPERATION)

A 10.1 During internal battery operation, the clock display is not lit in order to conserve battery power. To illuminate the clock display in this mode, actuate the TIME DISPLAY pushbutton.

A 11.0 PULSE ADVANCE MICROSEC

A 11.1 The timing of the pulses is adjusted via the PULSE ADVANCE MICROSEC thumbwheel switches on the front panel in seven (7) discrete steps of 100, 10, and 1 millisecond; and 100, 10, 1, and 0.1 microseconds, over a range of 1 second. This allows the 1 PPS lead edge, 1 PPM trailedge, and second mark trailedge to be coincident with each other within 1.0 microsecond.

A 12.0 TIMING FAULT OUTPUTS

A 12.1 Timing fault outputs are automatically available at the rear connector (P2), on the occurrence of a fault. During no-fault operation, the output level is in the range of 3.0 Vdc to 5.5 Vdc. During abnormal operation, the timing fault output level is in the range of 0 Vdc to 0.5 Vdc.

APPENDIX B

LINE POWER CONVERTER DATA

SPECIFICATIONS AND FEATURES

D.C. OUTPUT - Voltage regulated for line and load. See Table 1 for voltage and current ratings.

TABLE 1

MODELS	VOLTAGE RANGE	MAXIMUM CURRENT (AMPS)* AT AMBIENT TEMPERATURE				INPUT POWER (WATTS)**
		40°C	50°C	60°C	71°C	
LNS-W-5-OV	5±5%	14.0	12.2	10.0	7.5	220
LNS-W-6	6±5%	13.0	11.1	9.3	6.8	220
LNS-W-12	12±5%	8.5	7.2	5.9	4.2	255
LNS-W-15	15±5%	7.7	6.7	5.5	3.8	255
LNS-W-20	20±5%	6.1	5.2	4.2	3.0	255
LNS-W-24	24±5%	5.4	4.6	3.7	2.5	255
LNS-W-28	28±5%	4.7	4.0	3.2	2.2	255

Current range must be chosen to suit the appropriate maximum ambient temperture. Current ratings apply for entire voltage range.

*Ratings apply for use with cover removed. Derate current 15% for each ambient temperature if cover is used. Refer to Figure 11 for cover removal.

**With output loaded to full current rating and input voltage 127 volts AC, 60 Hz.

REGULATED VOLTAGE OUTPUT

Regulation (line)..........	0.1% for input variations from 105-127, 127-105, 210-254, or 254-210 volts AC.
Regulation (load)..........	0.1% for load variations from no load to full load or full load to no load.
Ripple and Noise...........	1.5m V rms, 5m V peak to peak with either positive or negative terminal grounded.
Temperature Coefficient....	Output change in voltage 0.03%/°C.
Remote Programming	
External Resistor........	Nominal 200 ohms/volt output.
Programming Voltage......	One-to-one voltage change.
Remote Sensing............	Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

OVERSHOOT - No overshoot under conditions of power turn-on, turn-off, or power failure.

AC INPUT - 105-127 or 210-254† volts AC at 47-440 Hz. Standard LNS-W power supplies are factory wired for 105-127 volt input, but can be rewired for 210-254 volt input. For input power see Table I. Ratings apply for 57-63 Hz input. For 47-53 Hz or 63-440 Hz input consult factory.

†Certified by Canadian Standards Association for 210-250 volt input.

OUTPUT PROTECTION

Thermal.................... Thermostat, resets automtically when over temperature condition is eliminated.

Electrical................. Automatic electronic current limiting circuit, limits output current to a safe value. Automatic current limiting protects the load and power supply when external overloads and direct shorts occur.

INPUT AND OUTPUT CONNECTIONS

AC input................... Screw terminals on printed circuit board

Ground..................... Terminal on transformer

DC output.................. Screw terminals on printed circuit board

Sensing....................Screw terminals on printed circuit board

Overvoltage Protection.....Quick disconnect terminals on printed circuit board with mating connectors attached.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE - Continuous duty from 0°C to 71°C ambient with corresponding load current ratings for all modes of operation.

STORAGE TEMPERATURE (non operating) - -55°C +85°C

FUNGUS - All LNS-W power supplies are fungus inert.

DC OUTPUT CONTROL - Screwdriver voltage adjust control permits adjustment of DC output voltage. Refer to Figure 11 for location of control.

PHYSICAL DATA

Size........................	9" x 5" x 2-7/8" with cover in place 9" x 4-7/8" x 2-3/4" with cover removed
Weight......................	9 lbs. net; 9-1/2 lbs. shipping
Finish......................	Gray, FED. STD. 595 No. 26081

MOUNTING - Three surfaces, two with tapped mounting holes and one with clearance mounting holes, can be utilized for mounting this unit. Air circulation is required when unit is mounted in confined areas.

"J" OPTION - All LNS-W power supplies can be obtained for 90-110 VAC, 47-440 Hz input. Ratings apply for 57-63 Hz input. For 47-53 Hz or 63-440 Hz input consult factory.

ACCESSORIES

Overvoltage Protector......	Internally mounted L-20-OV series Overvoltage Protectors are available.

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